PB-217 248

# DELAWARE ESTUARY COMPREHENSIVE STUDY. WATER USE ADVISORY COMMITTEE GUIDE

Public Health Service
Philadelphia, Pennsylvania

December 1964

DISTRIBUTED BY:

NTIS

National Technical Information Service
U. S. DEPARTMENT OF COMMERCE
5285 Port Royal Road, Springfield Va. 22151

PB 217 148

# Delaware Estuary Comprehensive Study

## WATER USE ADVISORY COMMITTEE GUIDE

U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
Public Health Service
Division of Water Supply and Pollution Control

Reproduced by
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. Department of Commerce
Springfield VA 22151

# A GUIDE FOR SUB-COMMITTEE MEMBERS

This guide has been prepared for those persons (a/o the organizations they represent) who serve on the four sub-committees of the Delaware Estuary Comprehensive Study's Water Use Advisory Committee.

DELAWARE ESTUARY COMPREHENSIVE STUDY (DECS)
Division of Water Supply and Pollution Control
Public Health Service
Department of Health, Education, and Welfare
321 Chestnut Street
Philadelphia, Pennsylvania 19106

Code 215 597-4360

December, 1964

1b

Table of Contents


| | Page |
|---|---|
| Table of Contents | 1 |
| Statement of Initial Request to Sub-Committees by DECS | 2 |
| Introduction | 3 |
| **PART I** | |
| 1. The Delaware Estuary Comprehensive Study (DECS) | 5 |
| A. Brief Description | 5 |
| B. The DECS Advisory Committee Structure | 6 |
| 2. Information Relative to Water Quality Indicators and Water Use | 12 |
| A. Abbreviated Definitions of Water Quality Indicators | 12 |
| B. Present Major Uses of the Estuary | 14 |
| C. Map Locating INCODEL Zones and Major Water Users | 15 |
| **PART II** | |
| 1. Explanation of Assignments | 17 |
| A. Phase I | 18 |
| B. Phase II | 20 |
| **PART III (Reference Material)** | |
| 1. Address by James W. Quigley, Assistant Secretary, Dept. of Health, Education, and Welfare | 22 |
| 2. The INCODEL Standards | 31 |
| 3. Definitions | 36 |
| 4. Water Quality Objectives and Guides | 37 |
| 5. Water Quality Criteria | 43 |

STATEMENT OF INITIAL REQUEST TO SUB-COMMITTEES OF THE WATER USE ADVISORY COMMITTEE BY THE DECS.

(Presented at the 2nd Meeting of the Sub-Committees)

The Delaware Estuary Comprehensive Study requests that the sub-committees of the Water Use Advisory Committee undertake as their initial task, the preparation of the first part of a report on the present and future use and needs (objectives) of the organizations represented, relative to the waters in the estuary. These uses and needs or water quality objectives should make use of indicators (or parameters) in the descriptive material, but as objectives they need not include quantitative information. Limits or ranges should be reserved for the second phase of the report.

The second phase will be requested after the Study, along with the Policy Advisory Committee and Technical Advisory Committee, have reviewed and returned the initial report to the Water Use Advisory Committee. Inter-committee discussions might delay the second phase to some extent. This should allow sufficient time for all sub-committee members to be able to obtain the information necessary for the second phase.

## Introduction

At the second meeting of the sub-committees of the Water Use Advisory Committee, the Statement on the previous page was given to those present. This requested that a report be prepared in two phases: (1) to determine, in general terms, what water quality objectives the organization he or she represented sought relative to the waters of the Delaware estuary; (2) to determine these same (or possible new or different) objectives in quantitative terms.

This guide was prepared to simplify these tasks for the sub-committee members, and to assist members in eliciting responses from the organizations they represent.

Part I of this guide briefly explains (1) the DECS and (2) the current quality and uses of the waters of the Delaware Estuary. Part I also contains a map showing the zones into which the estuary has been divided by the existing interstate water pollution control legislation. Also shown are the major municipalities and industries that use the water of the estuary.

Part II deals with YOUR ASSIGNMENTS. Please read this very carefully and use the following materials in wording the water quality objectives sought by your organization.

Part III contains certain reference materials that should be useful to all members of the four sub-committees.

For the general information of all sub-committee members:

1. The Delaware estuary is that 86 miles of the Delaware River stretching from Trenton, N.J. to Liston Point, Delaware that is subjected to the oscillating motion of the tides.

2. The existing zones of the estuary were originally promulgated in the "Reciprocal Agreement for the Correction and Control of Pollution of the Waters of the Interstate Delaware River". (A copy of the Agreement is contained in Part III of this guide). The "Reciprocal Agreement" was formulated under the auspices of the Interstate Commission on the Delaware River Basin (INCODEL) and have been commonly called the INCODEL Standards. The Delaware River Basin Commission, INCODEL's successor, has adopted the Standards as a part of it's Comprehensive Plan. They have been the basis for regulating the quality of the water of the entire main stem of the Delaware River since 1945.

Most of the materials contained in this guide have been prepared by the DECS staff. However, the DECS staff is particularly indebted to Mr. George W. Burke, Jr., Chief, Water Quality Criteria and Practices, Water Supply and Pollution Control Division of the U.S. Public Health Service, for permitting the use of much of his material on Water Quality, Mr. Frank Dressler, Executive Director of the WRA/DRB for his assistance in the initial phase of this guide, and members of all DECS committees who assisted in its development.

## PART I

1. The Delaware Estuary Comprehensive Study (DECS)
   - A. Brief Description
   - B. The DECS Advisory Committee Structure
2. Information Relative to Water Quality Indicators and Water Use*
   - A. Abbreviated Definitions of Water Quality Indicators**
   - B. Present Major Uses of the Estuary
   - C. Map Locating INCODEL Zones and Major Water Users

*Data on the present water quality of the Delaware Estuary is in the process of being compiled and will be made available.

**Specific information on the effects of various concentrations of water quality indicators will be made available.

## PART I

### 1. The Delaware Estuary Comprehensive Study (DECS)

#### A. Brief Description.

In late 1961 the Division of Water Supply and Pollution Control of the U.S. Public Health Service initiated the Delaware Estuary Comprehensive Study. The Study was requested by the States, INCODEL and the City of Philadelphia, who desired an intensive study of the area in which water quality was most critical. They wished to know the cause and effect relationships of pollution, the economic relationship between water and waste treatment, and water use. The study covers the length of the Delaware River from Trenton, New Jersey to Liston Point, Delaware. This 86 miles of river, known as the estuary, is encompassed by one of the most heavily populated and industrialized areas in the country.

Authorization for the study is derived from Section 2(a) of Public Law 660, 84th Congress 1956, as amended by Public Law 87, 88th Congress 1961, which is entitled "Comprehensive Programs for Water Pollution Control" and reads as follows:

> "The Secretary shall, after careful investigation in cooperation with other Federal agencies, with State water pollution control agencies and interstate agencies, and with the municipalities and industries involved, prepare or develop comprehensive programs for eliminating or reducing the pollution of interstate waters and tributaries thereof and improving the sanitary condition of surface and underground waters. In the development of such comprehensive programs due regard shall be given to the improvements which are necessary to conserve such waters for public water supplies, propogation of fish and aquatic life and wildlife, recreational purposes, and agricultural, industrial, and other legitimate uses. For the purpose of this section, the Secretary is authorized to make joint investigations with any such agencies of the condition of any waters in any State or States; and of the discharges of any sewage, industrial wastes or substance which may adversely affect such waters."

The Delaware Estuary Comprehensive Study is developing techniques for the accurate appraisal of the water quality of the estuary. These techniques include technical procedures for forecasting the estuarine water quality on both a short-t--- and a long-term basis. It is the intention of the Delaware Estuary Comprehensive Study to develop these approaches as they apply to comprehensive water pollution control, in cooperation with other agencies, and to provide a meaningful evaluation of the present and future steps which must be taken to result in an optimum level of quality in the estuary.

The technical procedures for forecasting the estuarine water quality involve the development of mathematical models for use with high speed computers. The models are general models which may be adapted to any one of several water quality parameters - such as dissolved oxygen, chlorides and turbidity. All the factors that significantly affect the dissolved oxygen concentration in the estuary are being expressed mathematically. A partial list of these factors includes photosynthesis, sunlight, temperature, carbon dioxide, nitrogen, domestic and industrial waste, storm water overflow, benthal deposits, hydraulics, reaeration, turbulence, stream flow, and wind. All of these must be considered and investigated, although some may not be as significant as others.

The use of the procedures being developed by the DECS will permit an accurate appraisal of the effect of the addition of new or enlarged municipal and industrial water supply systems or waste treatment facilities before they are constructed. Also, the best locations for such supplies or facilities may be determined.

As new data are generated, they may be coded and incorporated into the models immediately. This includes data which may expand or refine the models themselves - as for example, information from dye, tidal current meter, and photosynthetic studies, as well as changes in hydrography and new methods of waste treatment.

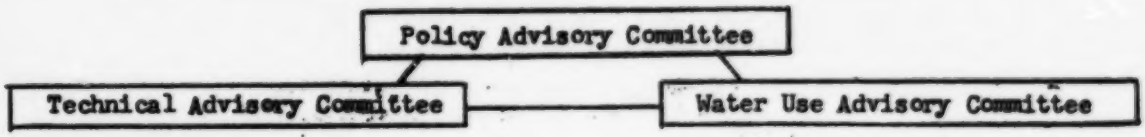
These new engineering techniques will provide a firmer basis for many decisions; however, the computers will not in themselves produce a plan. It still remains for the engineer to exercise sound judgment using data from all sources, including computers, when preparing the final Water Pollution Control Plan.

With the assistance of the various agencies involved, the Public Health Service's Delaware Estuary Comprehensive Project will provide a dynamic Water Pollution Control Plan which will be flexible and adaptable to future area changes and development, as well as consistent with both the economic environment and the desires of the people of the area.

B. The DECS Advisory Committee Structure.

In order to meet the requirements of Section 2(a) of Public Law 660 (See quote in Part I.A. of the Guide) the DECS, with the assistance of the states and the DRBC, developed a supporting Committee Structure which it considered would be best suited for the estuary basin.

The following pages present an outline of the Committee Structure now in operation.




Sub-Committees
- Industry
- Fish & Wildlife

Sub-Committees
- Recreation, Conservation, Fish & Wildlife
- General Public
- Industry
- Local Governments & Planning Agencies

1. Policy Advisory Committee

Membership

Agencies with the legal power to abate water pollution and to implement a comprehensive plan.

Delaware Water Pollution Commission
- Floyd I. Hudson, M.D., Executive Secretary, State Board of Health
- John Bryson, Director, Water Pollution Control Commission

New Jersey Health Department
- Alfred H. Fletcher, Director, Division of Environmental Health
- Robert Shaw, Asst. Director, Division of Environmental Health

Pennsylvania Health Department
- Karl M. Mason, Director, Bureau of Environmental Health
- Walter A. Lyon, Director, Division of Sanitary Engineering

Delaware River Basin Commission
- James F. Wright, Executive Director
- Herbert Howlett, Chief of Planning

U. S. Public Health Service
- Earl J. Anderson, Regional Program Director, Region II (Chairman)
- Everett L. MacLeman, Project Director, DECS

Members of the Policy Advisory Committee are responsible for representing other state and federal agencies, especially those with related water resources programs. Personnel of the other agencies are invited by the members to attend meetings of the Policy Advisory Committee. (To date, representatives from the Corps of Engineers, Department of Interior, and Department of Agriculture have attended meetings, while copies of minutes have been forwarded to various state agencies.)

Functions:

A. Attain consent among states on pollution abatement policy and plans and assure full coordination of effort and understanding.

B. Coordinate and assist in the inclusion of established water pollution control plans in overall comprehensive Water Quality Plan.

C. Relate Study to possible interim procedures for pollution abatement.

D. Advise the P.H.S. relative to the present DECS and future studies involving water pollution control in the estuary.

2. Technical Advisory Committee

Membership

I Agencies participating in work of study
II Personnel familiar with technical aspects of water quality control

Delaware Water Pollution Commission
W.C. Vasuki, Assistant Engineer

New Jersey Health Department
Harry M. Hughes, Principal Health Engineer

Pennsylvania Health Department
George A. Elias, Regional Engineer, Region VII
Kenneth Schoener, Asst. Chief, Stream Quality Section, Delaware River Basin

Delaware River Basin Commission
Robert A. Buckingham, Head, Water Quality Branch

City of Philadelphia
Joseph Radziul, Chief, Research & Development Unit, Water Department

Industry
Lloyd Falk, Waste Consultant, E.I. duPont de Nemours & Co.

U.S. Fish and Wildlife Service
George Spinner, Supervisor, Trenton Area Office

Bureau of Outdoor Recreation-

U.S. Public Health Service
Robert V. Thomann, Technical Director, DECS (Chairman)

Functions:

A. Keep agency represented appraised of the status of the DECS - in this manner the agency has one of its personnel who has a complete understanding of the technical phases of the DECS.

B. Assist P.H.S. in planning and coordinating DECS.

C. Provide technical assistance.
   1. assist in the organizing of various projects
   2. provide additional qualified personnel for special phases of study
   3. review preliminary drafts of reports
   4. advise Policy and Water Use Committee on technical matters.

3. Water Use Advisory Committee

Membership

Recreation, Conservation, Fish and Wildlife
Edmund H. Harvey, President, Delaware Wildlife Federation

General Public
Frank W. Dressler, Exec. Director, Water Resources Assoc./ Delaware River Basin

Industry
William B. Halladay, Supervisor-Pollution Control, The Atlantic Refining Company

Local Governments and Planning Agencies
Carmen F. Guarino, Chief, Sewerage Operations, City of Philadelphia

U. S. Public Health Service
Everett L. MacLeman, Project Director, DECS (Chairman)

Functions:

A. Indicate the needs and desires of the people of the estuary relative to water use with water quality as a criterion. (It is for this function that this guide was developed - also see Part I,2).

B. Act as a public relations group.

C. Assist in special non-technical phases of the DECS.

Sub-Committee Membership (November 1964)

(1) Recreation, Conservation and Fish and Wildlife

A. Shellfish Industry
B. Audubon Society
C. Pennsylvania Pleasure Boat Association
D. Delaware River Yachtsmen League
(Corinthian Yacht Club)
E. Pennsylvania Federation of Sportsmen's Clubs
F. New Jersey Federation of Sportsmen's Clubs
G. Delaware Wildlife Federation
H. Izaac Walton League
I. Philadelphia Conservationists
J. Outdoor Writers' Association of America
K. Marine Resources Committee

(2) General Public

A. WRA/DRB
B. League of Women Voters
C. Federation of Women's Clubs
D. Delaware Valley Council
E. Joint Council of Pennsylvania Farm Organizations
F. New Jersey Farm Bureau Federation
G. New Jersey State Grange
H. American Water Works Association
I. Delaware State Grange
J. Water Pollution Control Federation
K. Delaware River Watersheds Association
L. Pennsylvania State Chamber of Commerce
M. New Jersey State Chamber of Commerce
N. Delaware State Chamber of Commerce
O. Greater Philadelphia Chamber of Commerce
P. Pennsylvania Economy League
Q. Forward Lands, Inc.

(3) Industry

A. N.J. Manufacturers' Assoc.
B. Penna. Manufacturers' Assoc.

Petroleum

A. Texaco, Inc.
B. Gulf Oil Corp.
C. The Atlantic Refining Co.
D. Mobil Oil Co.
E. Sinclair Refining Co.
F. Sun Oil Co.
G. Tidewater Oil Co.

Steel

A. U.S. Steel Corp.
B. The Colorado Fuel and Iron Corp.
C. H.K. Porter Co., Inc.

Electric Utilities

A. Public Service Electric & Gas Co.
B. Philadelphia Electric Co.
C. Atlantic City Electric Co.
D. Delaware Power & Light Co.

Paper

A. Paterson Parchment Paper Co.
B. Bestwell Gypsum Co.
C. MacAndrews & Forbes Co.
D. Scott Paper Co.

Food

A. Kind & Knox Gelatin Co.
B. National Sugar Refining Co.
C. Campbell Soup Co.

Chemical

A. Hercules Powder Co.
B. Cary Chemical Co.
C. Rohm & Haas Co.
D. Allied Chemical Corp.
E. Harshaw Chemical Co.
F. E.I. DuPont de Nemours & Co.
G. Shell Chemical Co.
H. Penna. Industrial Chemical Corporation
I. The Monsanto Co.
J. Atlas Chemical Ind., Inc.
K. N.J. Zinc Co.
L. FMC Corporation

Miscellaneous

A. Eastern Gas & Fuel Assn.
B. Radio Corp. of America
C. Westinghouse Electric Corp.
D. Linde Co.
E. U.S. Gypsum Co.

Distillers

A. Publicker Industries, Inc.

(4) Local Governments and Planning Agencies

A. City of Burlington
B. City of Bristol
C. City of Camden
D. City of Chester
E. City of Dover
F. City of Philadelphia
G. City of Trenton
H. City of Wilmington
I. Levittown, Pennsylvania
J. Regional Conference of Elected Officials
K. Delaware State Planning Commission
L. Delaware River Port Authority
M. N.J. League of Municipalities
N. N.J. Bureau of State & Regional Planning
O. Penn-Jersey Trans. Study
P. Pa. State Planning Board
Q. Pa. State Assoc. of Boroughs
R. Pa. League of Cities
S. Pa. State Township Supervisors Assoc.
T. Pa. Municipal Authorities Association
U. Lower Bucks County Municipal Authority

## 2. Information Relative to Water Quality Indicators and Water Use

### A. Abbreviated Definitions of Some Water Quality Indicators

#### (a) Temperature

Temperature may be defined as the degree of hotness or coldness measured on a definite scale. A common unit of temperature is the Fahrenheit degree. It should be noted that the maximum dissolved oxygen saturation is higher at lower temperatures. For example, at 32°F the saturation value is 14.6 mg/l, while at 77°F it is 8.4 mg/l. Temperature changes in streams or bodies of water may result from natural climatic phenomena or from the introduction of industrial wastes, such as the discharge of cooling water. Temperature is important and sometimes critical for many uses of water. It affects palatability, treatment processes, natural purification, many industrial uses and the suitability of the water as a habitat for aquatic life.

#### (b) Chlorides

Chlorides are an approximate measure of the amount of saltwater that has mixed with fresh water. Chloride contamination of a water course may result from saltwater intrusion, sanitary sewage, or from industrial effluents.

#### (c) Dissolved Oxygen

Various levels of dissolved oxygen are necessary to maintain aquatic life and to facilitate natural purification of the normally occurring organic matter and man-made wastes in streams. The oxygen concentration of a body of water is supplied through aeration, algal photosynthesis, and incoming fresh water and is utilized primarily in the stabilization of organic matter. (See temperature section for oxygen saturation-temperature relationships.)

#### (d) pH

pH is a measure of the relative alkalinity or acidity of a liquid. A pH of 7 is neutral while values higher than 7 are considered alkaline and values below 7 are regarded as acidic.

#### (e) Turbidity

Turbidity of water is attributable to suspended and colloidal matter which give a murky appearance to the water and diminishes the penetration of light. Turbidity may be caused by suspended solids which may result from natural processes of soil erosion or from the addition of domestic or industrial waste. Turbidity reduces light penetration, thus decreasing algal photosynthesis and the productivity of the organisms upon which fish feed.

(f) Coliform Bacteria

Coliform bacteria are used as an indicator of pollution on the basis of their being present in large numbers in the fecal discharges of warm blooded animals and the ease with which their presence may be determined. For the specific identification of pathogenic (disease causing) bacteria and the elimination of interference due to coliform bacteria of soil origin, additional more complicated tests are necessary. There are two primary techniques for detecting coliform organisms, the older is referred to as the Most Probable Number (MPN) test. The newer method is the Membrane Filter Technique (MF). A quantitative relationship between the two tests has not been established; however, on comparable samples the results of an MF test will generally be lower than those of the MPN.

Limits have been set by most states for the concentration of coliform bacteria in bathing waters. The bacterial requirements of water for industrial use vary widely.

(g) Phenols

Phenols are by-products of certain manufacturing processes. The presence of phenols in water will produce a disagreeable taste when combined with chlorine.

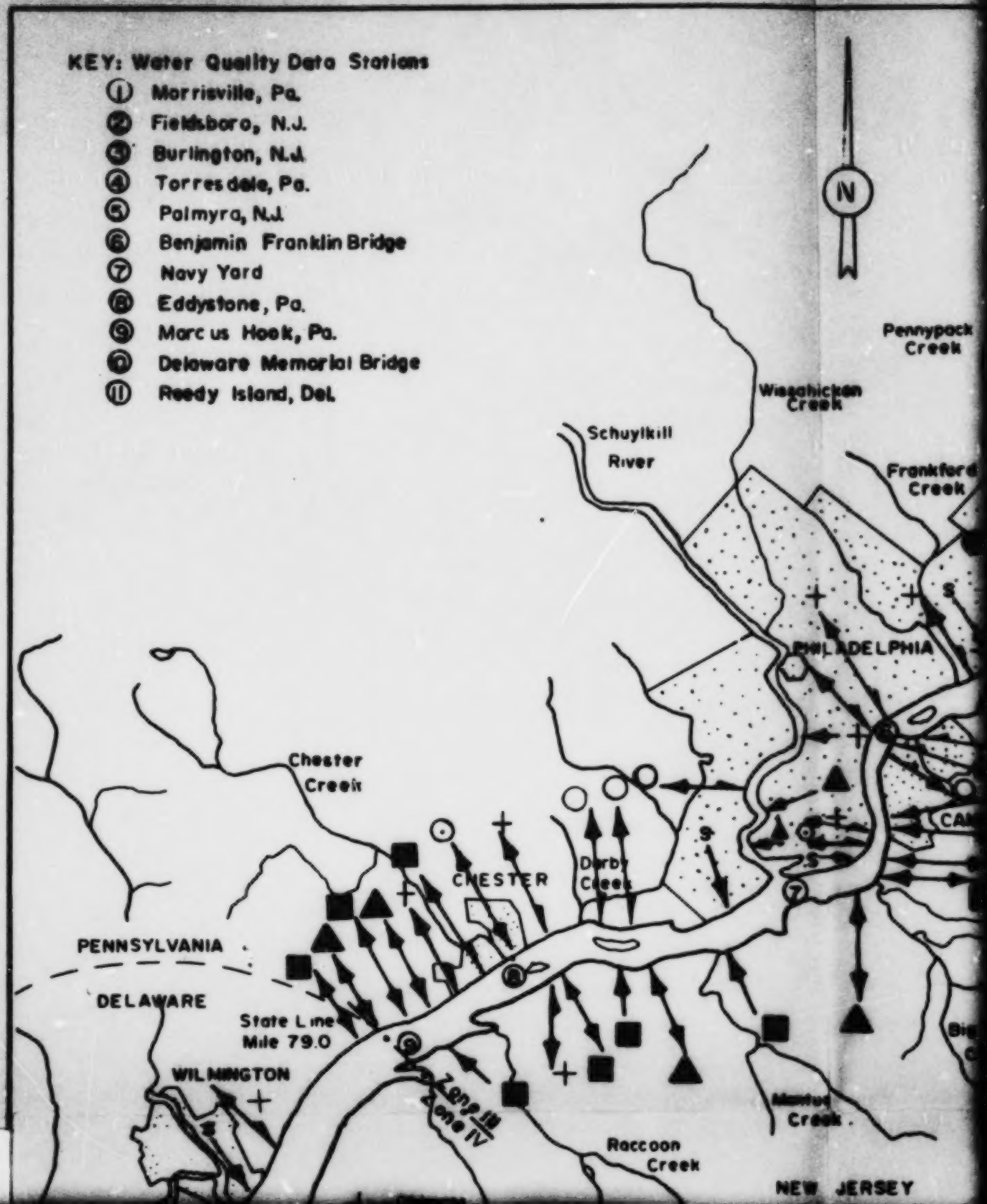
(h) Synthetic Detergents (ABS)

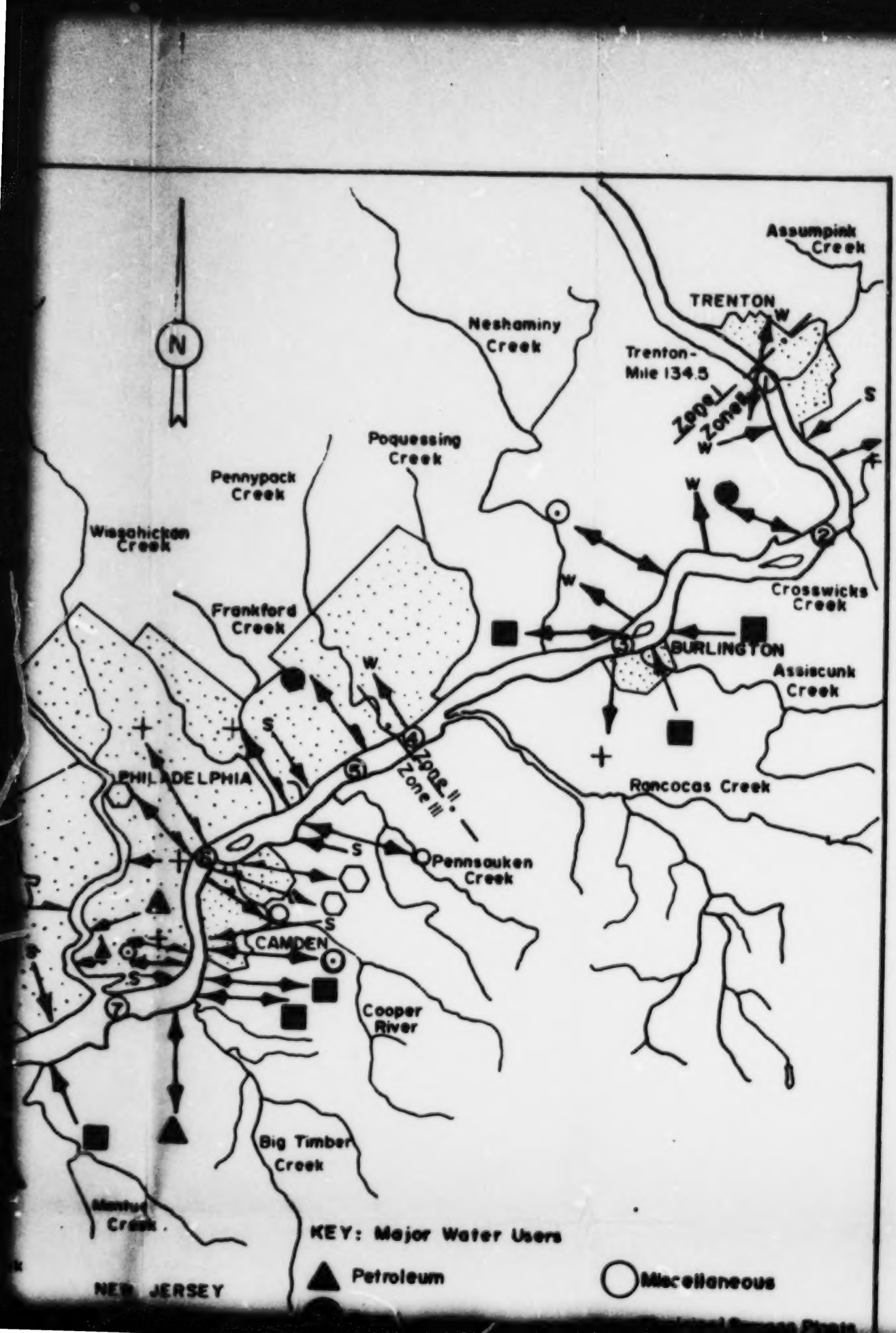
ABS is the measure of the concentration of a type of detergent presently in use. Most detergents in use today are not easily degradable by conventional methods of waste treatment. Their presence in a stream above certain concentration may cause a nuisance condition manifesting itself as unsightly foam.

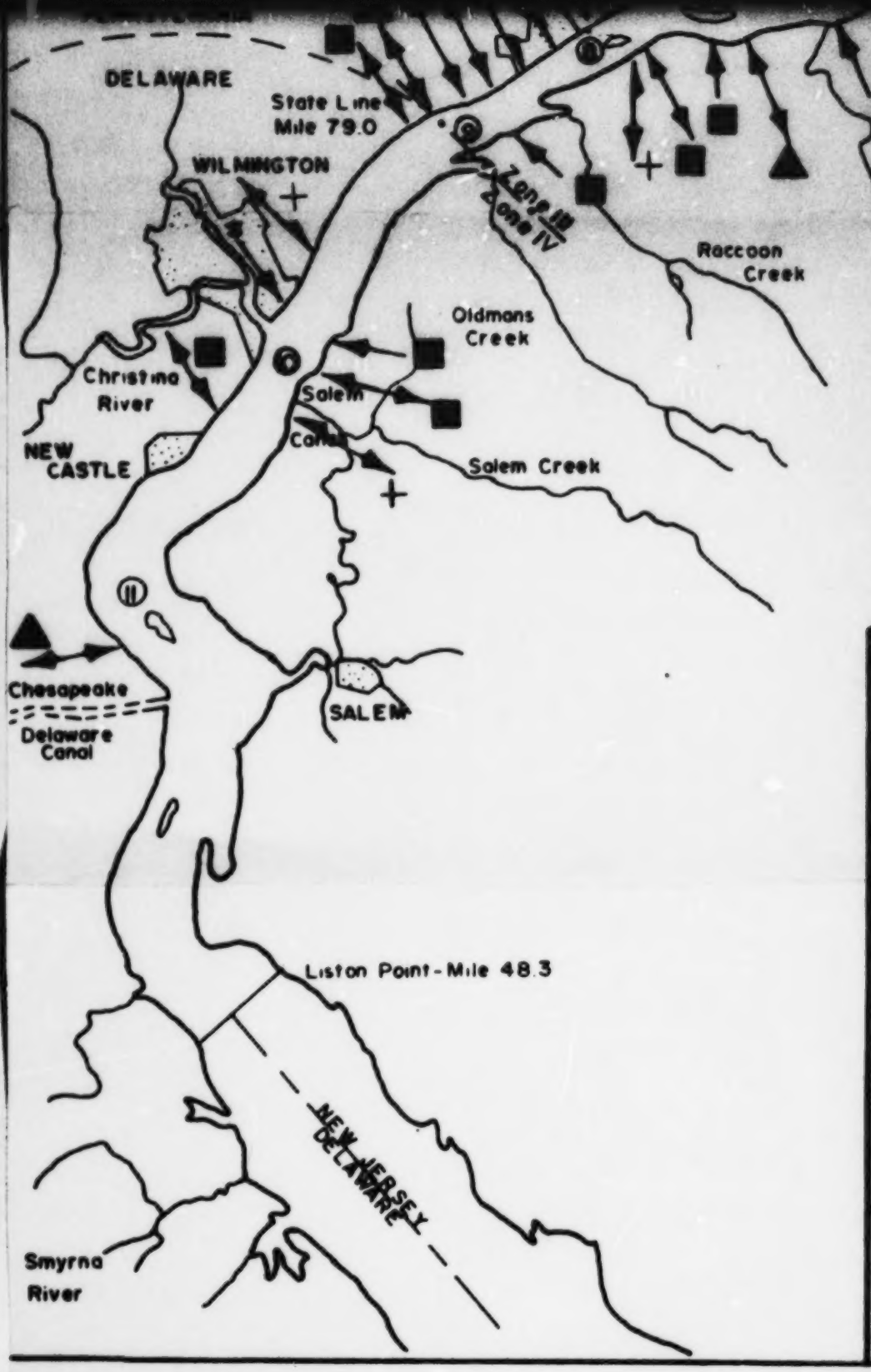
B. Present Major Uses of the Estuary

Figure 1 presents information on the withdrawal and discharge of water by the major municipal and industrial installations along the estuary. It can be noted that these water use activities are heavily concentrated in the Zone III area, although withdrawal of water for municipal purposes is limited to Zone II.

More specifically, present uses in Zone II include boating, water skiing, some sport fishing and municipal and industrial water supply and waste disposal. Navigation, waste disposal, industrial water supply (mostly cooling water) and some boating constitute the primary water uses in Zone III. The waters of Zone IV are used primarily for navigation, industrial cooling water, waste disposal, boating, sport and commercial fishing and some bathing. The latter two uses are concentrated primarily in the middle and lower portions of the Zone.


KEY: Water Quality Data Stations
(1) Morrisville, Pa.
(2) Fieldsboro, N.J.
(3) Burlington, N.J.
(4) Torresdale, Pa.
(5) Palmyra, N.J.
(6) Benjamin Franklin Bridge
(7) Navy Yard
(8) Eddystone, Pa.
(9) Marcus Hook, Pa.
(10) Delaware Memorial Bridge
(11) Reedy Island, Del.
N
Pennypack Creek
Wissahickon Creek
Schuylkill River
Frankford Creek
PHILADELPHIA
Chester Creek
CHESTER
Darby Creek
PENNSYLVANIA
DELAWARE
State Line Mile 79.0
WILMINGTON
Zone III
Zone IV
Raccoon Creek
NEW JERSEY


N
Assunpink Creek
TRENTON
Neshaminy Creek
Trenton-Mile 134.5
Zone I
Zone II
Poquessing Creek
Pennypack Creek
Wissahickon Creek
Crosswicks Creek
Frankford Creek
BURLINGTON
Assiscunk Creek
PHILADELPHIA
Zone II
Zone III
Rancocas Creek
Pennsauken Creek
CAMDEN
Cooper River
Big Timber Creek
Mantua Creek
KEY: Major Water Users
Petroleum
Miscellaneous
NEW JERSEY



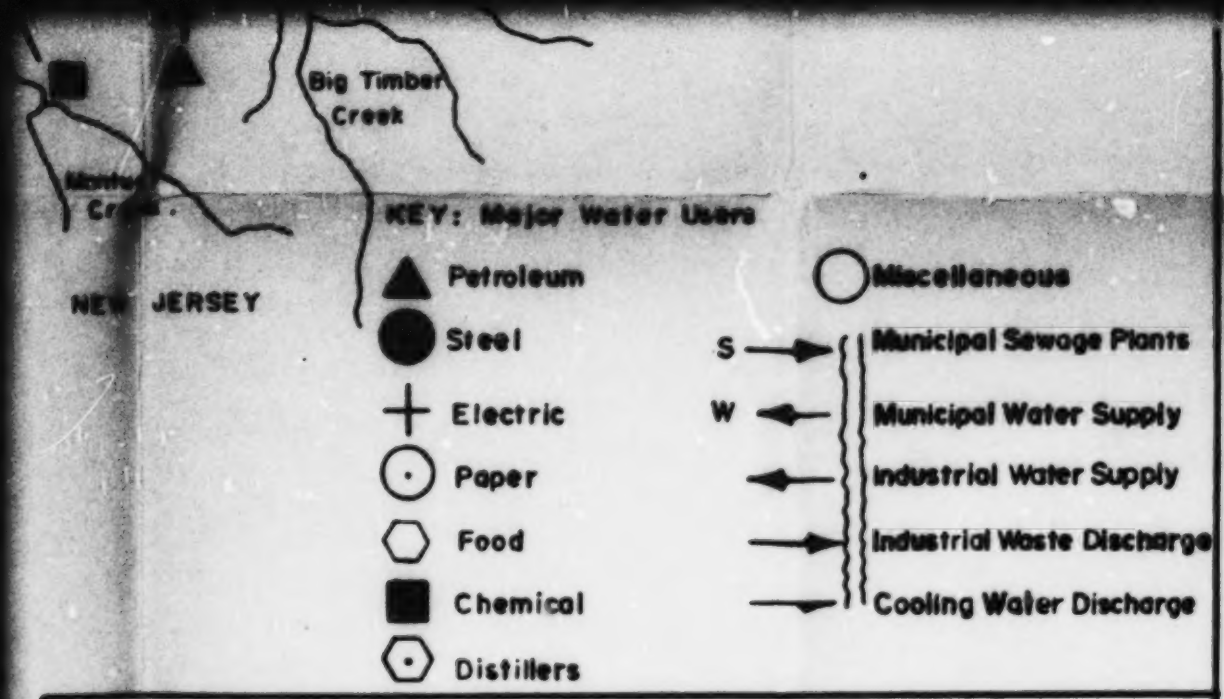

DE
COM

WATE

SCALE MILES

U.S. DEPARTM

DIVISION OF
REGION II




# DELAWARE ESTUARY COMPREHENSIVE STUDY

FIGURE 1

INCODEL ZONES

MAJOR WATER USERS

WATER QUALITY DATA STATIONS

SCALE MILES 5 0 5 10

U.S. DEPARTMENT OF HEALTH, EDUCATION, & WELFARE

PUBLIC HEALTH SERVICE

DIVISION OF WATER SUPPLY & POLLUTION CONTROL

REGION II NEW YORK, NEW YORK

## PART II

1. Explanation of Assignments

   A. Phase I

   B. Phase II

## PART II

1. Explanation of Assignments

At the first and second meetings of the sub-committees, the DECS's Project Director explained, procedurally, how the work of the sub-committees would dovetail with the work and conclusions of the DECS. In brief:

1. Each member of the sub-committee is expected to elicit from the organization which he or she represents just what water quality objectives the organization seeks relative to the water resources of the Delaware estuary.

2. Each sub-committee will then meet and review the water quality objectives developed by each member organization or work group of organizations and prepare a report by April 1, 1965 summarizing the ideas of the sub-committee.

3. The reports of the four sub-committees with a summary prepared by the Water Use Advisory Committee correlating the work of the sub-committees, will constitute Phase I of the report requested by the DECS. The Water Use Advisory Committee will meet on April 15, 1965 to undertake the preparation of the summary.

4. Phase I of the Report will be reviewed by the Staff of the DECS and members of the Policy Advisory Committee and the Technical Advisory Committee. Comments and questions will then be directed to the Water Use Advisory Committee.

5. Phase II of the Report will include, as previously indicated, quantitative information with the stated objectives of Phase I serving as guides. At that time, the DECS will be preparing an interim report utilizing the information set forth in Phase I. In addition, information on cost benefits from recreation, fish and wildlife might also be available.

6. The reports of the four sub-committees with a summary prepared by the Water Use Advisory Committee correlating the work of the sub-committees, will constitute Phase II of the report requested by the DECS.

7. Phase II of the Report will then be reviewed by the Staff of the DECS and members of the Policy Advisory Committee and Technical Advisory Committee. Comments and questions will then be directed to the Water Use Advisory Committee.

A time schedule for the above assignments will be prepared at a later date.

A. Phase I

The immediate assignment of all members of all four sub-committees is to elicit from the organization he or she represents the water quality uses and needs (objectives) his or her organization seeks relative to the waters in the estuary. If possible, these uses and needs, or water quality objectives, should make use of the indicators in the descriptive material.

A Water Quality Indicator may be defined as follows: "A water impurity or characteristic which serves as a measurement of quality and the suitability of water for particular uses. Examples of indicators are: DO (dissolved oxygen), BOD (biochemical oxygen demand), pH, chloride, and sulfate."

In handling its assignment, each organization that is represented on the four sub-committees should ask and answer these questions:

1. What uses does this organization (or the members thereof) make of the waters in the estuary now? What needs of this organization do these waters now fill?

2. In the future, what uses do we hope to make of the waters in the estuary? Or what needs of ours do we look to the waters in the estuary to fulfill in the future?

For some of the organizations, the answers to the two questions in the most general terms will be the water quality objectives they seek for the estuary. While it will be desirable in most cases that these objectives include indicators, the use of indicators is not expected from all organizations.

Quite obviously, most industries, municipalities and recreation groups will want to use indicators in describing their water quality objectives. If you do use indicators, please use them in general terms, that is, don't attempt to specify limits or ranges. Limits or ranges will be dealt with in Phase II.

The attached paper entitled "Water Quality Objectives and Guides" should be extremely helpful in the development of Phase I.

The following outline is one form which may be used in the preparation of Phase I:

Sub-Committee: Recreation, Conservation, Fish and Wildlife

Group: Boating

Subject: Present and Future Water Uses and Needs of Pleasure Boats on the Estuary.

Participants:
1. ABC Boating League
2. Area Yachtsmen's Association
3. Marina Owner's Association

I. Present Uses

A narrative with some statistical data on the facilities, type of craft, type of activity, etc., should be included in this section. It will be necessary in the narrative to relate the present use to areas of the estuary.

II. Future Desired Uses

A narrative similar to that of Section I should cover the future uses which the group feels would be desirable in the different areas.

III. Effect of Water Quality on Use

This section should include a discussion of the restrictions, if any, on boating that are imposed by the present water quality. An indication should also be given of the water quality levels that are necessary for the fulfillment of future boating desires.

B. Phase II

Before Phase II is reached, the Water Use Advisory Committee will have reached a joint understanding on generally stated water quality objectives for the estuary. The achievement of joint understanding may be difficult in some cases. For example, some organization might like the quality of all the estuary's waters to be such that they can be used for drinking water purposes some time in the future. This is not likely to be an attainable objective simply because the oscillating motion of the tides makes some parts of all estuaries very salty at all times (that is, the waters have a high concentration of chlorides).

Other organizations are likely to want fairly high minimum levels of certain indicators to enhance the passage or growth of some species of fish. The achievement of this minimum level may be costly and may have an adverse economic impact on this region. For example, DECS has determined that to achieve a minimum dissolved oxygen level of 4.0 parts per million in critical sections of the estuary would require a probable total investment in waste treatment facilities on the order of several hundred million dollars. The Water Use Advisory Committee, thus, will have to determine if such objectives are feasible.

In making such determinations, it is likely that some objectives sought by some organizations will not be attainable.

With this preliminary explanation, the assignment you will be asked to handle in Phase II will be somewhat clearer.

If the water quality objectives your organization specified it would like to see achieved (in Phase I) are shown to be attainable in part or whole, your organization will then be asked to define these objectives quantitatively, that is, you will be asked to establish indicator limits or ranges. Numerous examples of such limits or ranges will be found in Part III. If your objective is regulated by certain common standards (for example, the U.S. Public Health Service's drinking water standards), copies of such standards will be made available to you.

The attached paper entitled "Development of Water Quality Goals" should be of assistance in the preparation of Phase II.

Sub-committee chairmen have been given copies of the USPHS "Drinking Water Standards" and the publication "Water Quality Criteria" prepared by the Resources Agency of California for the State Water Quality Control Board. Both of these publications should provide considerable assistance.

## PART III

The selected material included in Part III is for reference to be used as needed.

## PART III

1. Address by James M. Quigley, Assistant Secretary, U.S. Department of Health, Education, and Welfare . . . . . .

2. The INCODEL Standards . . . . . .

3. Definitions . . . . . .

4. Water Quality Objectives and Guides, Mr. George W. Burke . . . .

5. Water Quality Criteria, Mr. George W. Burke . . . . . .

# ADDRESS *

By
James M. Quigley
Assistant Secretary, U.S. Department of
Health, Education, and Welfare

It is a pleasure for me to be here and to have the opportunity to participate in this annual Delaware River Basin Water Resources Conference.

These conferences have been held each year for more than a generation. In that time an awful lot of water has gone under many bridges and much of it has been polluted. Because this was true thirty years ago wise and prudent men were moved to call the first of these conferences. Because it is still true it is still wise and prudent that we continue to meet to consider and discuss the problems of water resources in the Delaware River Basin.

Such discussions in and of themselves will neither advance nor retard the development of the water resources of the Delaware. Words are one of the few things that man can use freely -- can even abuse -- without polluting our water resources. At least they do not pollute directly. Obviously if we talk too long when we should be acting, if needless words become a substitute for needed action, then what we say can be a contributing factor to the lowering of water quality.

But those who are familiar with the work of these annual conferences would agree that, while the word quality may not always have been of the highest, (This is the chance you take when you invite an after dinner speaker like myself) that generally the words used in these meetings, the discussions which have taken

---

*Delivered at the Annual Delaware River Basin Water Resources Conference, The Inn, Buck Hill Falls, Pennsylvania, October 19, 1964, 7:15 p.m.

place at your annual conferences have been the prelude to and not a substitute for effective action. The good people who have been the moving force behind these conferences can look back with satisfaction on what has been accomplished. Despite the many frustrating delays, despite the failure to achieve some of your goals, much that has been done, much that would have gone undone, has resulted directly and indirectly from your annual conferences.

Because I believe this will continue to be true in the future, I am grateful for this opportunity to discuss with you one of the most complex problems, one of the difficult challenges we face -- the matter of preserving, protecting and restoring water quality.

In the July 1963 issue of the Delaware Basin Bulletin it was noted that "perhaps the most difficult and complex water problem that will have to be faced in the Delaware Basin in the near and far future is that of water quality." I wish I could disagree with that statement but I can't. I wish I could come before you this evening and say, while that might have been true when it was written in July 1963, it is no longer the case. If I did, I would not fool you or myself and I have no desire to do either.

The problem of preserving, protecting and restoring the water quality in the Delaware River Basin, as in many other areas of our country, is a formidable challenge. To belittle it would be a mistake. However, to over-estimate it would be equally erroneous. Because you have struggled long and so far without complete success to develop and implement a realistic set of water quality standards for the Delaware River doesn't mean that it can't be done. In fact, this is all the more reason why it must be done. Unless a comprehensive water quality program can be developed with dispatch and implemented with determination, the long ranged potential for the growth of this area is certain to be limited.

This is so for the very obvious reason that the quality of available water pretty much determines what can -- and perhaps even more important -- what cannot be done. To cite the most obvious example, you may sail or swim in water with a high salt quality but you won't drink much of it and it's not what you need if you want a bumper crop.

The Delaware River is one of the great rivers of the world. It is not as mighty as the Mississippi nor as long as the Nile. In the language of Detroit I suppose it could only be called a compact. But, in the language of one well-known automobile ad, one might be tempted to describe it as "the best all-round compact anyone has come up with yet." For within its relatively short run from the Catskills to the bay, the Delaware does an all-round good job of supplying drinking water to our municipalities and recreational waters for our sportsmen. The Delaware furnishes water in sufficient volume to sustain one of the great industrial complexes in the world. And for a substantial portion of its length it's in sufficient depth to encourage the growth of some of the finest port facilities. Many rivers twice as long do not help men half as much as the Delaware.

Man has used the Delaware well, but man can't do everything he's done with the Delaware River and not pay a price. Part of that price has been a deterioration of the quality of the water which flows within its banks. The challenge we face is: first, maintain the quality of this river where it is good; second, keep it from getting worse; and, third, to improve it where possible.

To these ends, the U.S. Public Health Service is, as you are all well aware, engaged in making a comprehensive study of the Delaware Estuary. This study seeks to compile a complete and detailed inventory of the source of pollution in the entire basin. This information is essential to the development of any intelligent over-all water quality plan. The development of such a plan for the Delaware is the second phase of our Department's study. And it is, as you can easily appreciate, the more difficult part of our assignment.

Gathering the facts is one thing, deciding what you do with them is another. In developing this comprehensive plan for the Delaware River we must first find out where we are but then we must decide where we want to go. Such a decision involves very difficult value judgments as to present and potential water uses. Certainly an unclouded crystal ball would indeed be a very handy device at a certain critical stage of this study. However, without the gift of prophecy but with the benefit of all the facts that deligent surveyirg and high speed computers can make available to us and with the aid of the best advice we can get from representatives of industry, conservation, recreation, farm and civic organizations, we will do our best to develop a sound and feasible comprehensive pollution control program for the Delaware River Basin. We have no illusions that such a plan will be perfect and that it will not have its critics and even its detractors. But for what it will be worth it is our present intention to do our best and hope to complete our study and submit our report by 1967.

And what will this PHS Delaware Estuary study be worth? The answer could be a great deal or absolutely nothing or something in between. What

the final answer will be depends on how effectively it is implemented.

The best study, the most comprehensive plan, isn't worth anything unless and until something is done about it.

A classical case in point is to be found in the history of the INCODEL Standards. Back in 1939, twenty five years ago, INCODEL promulgated standards of water quality for the main stem of the Delaware. These were not a bad set of standards at the time they were promulgated but it was 1945 before these standards were finally adopted by all of the basin states. Once adopted, the enforcement of these standards and the equally important matter of quality of the water of the Delaware's many tributaries was in the hands of the basin states. How well or how poorly the states carried out their responsibilities in this regard is not something that needed be commented upon at this time. The Delaware is a better river because of INCODEL's standards. How much better it might have been had they been fully implemented is a matter of speculation.

This bit of history should help us appreciate the challenge now confronting the Delaware River Basin Commission. Unless the Public Health Service's Estuary Study becomes the basis for effective and efficient and continuing pollution abatement activities then the quality of the water in the Delaware basin is almost certain to be in one direction -- downward. And, if this proves to be the fate of water quality in the Delaware, it is difficult to visualize the future of the Delaware River Basin moving in a contrary direction.

We are all here because we realize the importance of maintaining a balanced water quality in the Delaware. We are all here because we believe that the unique partnership of the states and the Federal government embodied

in the Delaware River Basin Commission affords the best chance yet of achieving this needed water quality. The Federal government through the Corps of Engineers, the U.S. Geological Survey, and the Public Health Service especially and through numerous agencies and departments of the Federal Government generally has, and, I am confident, will continue to make a full contribution to the effective working of this partnership.

There is a big job to be done. Working together, I believe we can do it. The answers will not always be easy and they will very often be expensive and in this imperfect world of ours it is to be expected that the cost will not always be equitably distributed. Some industries and some municipalities may in fact have to pay more than their fair share of the cost and all them will no doubt be convinced that they are doing so.

But the alternative of not doing the job will prove to be far more expensive and unfair to everybody. Unfair in the sense that to limit the growth and development of this area is indeed to restrict the common good. And surely none of us deceive ourselves on the vital point that there is a direct correlation between water quality and sound economic and social development.

This is the challenge inherent in the question of water quality in the Delaware River Basin. The PHS Survey should provide us with a sound basis for meeting that challenge. It should not moreover serve as an excuse for not facing up to it. Because the survey will not be completed until 1967 is no excuse why existing pollution situations should not be corrected between now and that date.

To those who might be tempted to say, "Why do anything now because when the new standards are promulgated we'll probably have to do more", I

would answer: "You're right and you're wrong." Because you are probably right in assuming that you will have to do more in the future is not a valid excuse for doing nothing now. I find it necessary as Assistant Secretary, to point out that the same law under which the Public Health Service is conducting its comprehensive study of the Delaware River also authorized the Secretary of Health, Education, and Welfare to bring an enforcement action to abate interstate pollutions. These are not alternate approaches to the problem. The mere fact that our Department is engaged in the comprehensive survey does not mean that an enforcement action is suspended and can not be called under the Federal Water Pollution Control Law.

Quite obviously, however, if the survey is moving forward in good order and there is every indication that it is part of an orderly process for improving the quality of the Delaware River, it could be argued that more good would be accomplished more quickly by not simultaneously proceeding on two separate routes -- via the enforcement and comprehensive route. I personally find merit in that position. But surely if the making of a survey is used covertly or openly as an excuse for not abating present pollution and that pollution falls within the purview of the Federal statute then it is difficult to perceive how the enforcement provisions of that law can long remain inoperative.

I trust I have made my point. We in our department have our responsibility and authority under the law. It is not a responsibility that we seek to avoid nor an authority that we wish to throw around and abuse.

As part of the Federal establishment, the Department of Health, Education, and Welfare is anxious to do everything it can to enable Uncle Sam to be an active, constructive participating partner in the partnership unique arrangement which is the Delaware River Basin Commission. To date, I believe we have been. By working together I am confident that we can and will develop and effectuate a comprehensive program for pollution control which will assure water of quality in the Delaware River Basin for all legitimate purposes. If we fail to achieve this objective, history will judge us harshly and it should.

# Reciprocal Agreement for the Correction and Control of Pollution of the Waters of the Interstate Delaware River.

(INCODEL Standards)

## Article I

Each of the signatory States pledges to each of the other signatory States faithful cooperation in the control of future pollution and in the correction of existing pollution of the waters of the interstate Delaware river and its west branch from the New York - Pennsylvania boundary line down to the Atlantic ocean. In order to effect such objects, each of the States agrees to enact adequate legislation, if necessary, to enable each such State so to require the treatment of sewage, industrial waste or other artificial polluting matter as to place and maintain the waters of the aforesaid interstate Delaware river, and of the tributaries thereof just above the confluence with the Delaware river, in the clean and sanitary condition required by the provisions of this agreement. Furthermore, each such State agrees so to enforce the provisions of these requirements, and other supplementary applicable legislation, if any, as to bring about the attainment of the objectives of pollution control and correction in accordance with such reasonable and effective programs as may be determined from time to time by the States in the manner prescribed herein.

## Article II

It is recognized by the signatory States that due to such variable factors as location, size, character, and flow, and of the many varied uses of the waters of the interstate Delaware river and its aforesaid west branch, such as water supply, recreation, navigation, industrial developments, maintenance of fish life, shellfish culture, agriculture, and other purposes, that no single standard of sewage and waste treatment and of quality of receiving waters is practical for all parts of the river. Therefore, in order to apply minimum requirements for the attainment of correction and control of pollution which will be appropriate to the varied factors including the existing and potential quality and uses of the waters, the interstate Delaware river is hereby divided into four zones, to wit:

Zone I: Zone one is that part of the Delaware river and its west branch extending from the New York - Pennsylvania boundary line to the head of tidewater at Trenton, New Jersey, and Morrisville, Pennsylvania.

The drainage basin contributary to this zone, excepting part of the Lehigh River Basin, is relatively sparsely inhabited and contains few sewered communities and relatively few industrial establishments producing waste water. The streams draining this area being, in general, relatively clean and of high elevation are well adapted as sources of public water supplies, after treatment or purification.

The principal uses of the waters of the Delaware river in Zone one are expected to be for water supply after such treatment or purification as may be necessary, and for recreation, bathing, maintenance of fish and aquatic life, agriculture, and for other related purposes.

Zone II: Zone two is that part of the Delaware river extending from the head of tidewater at Trenton, New Jersey, and Morrisville, Pennsylvania, to a line drawn perpendicular to the channel of the Delaware river from the mouth of Pennypack Creek in Philadelphia, Pennsylvania, to the corresponding point on the New Jersey shore.

The drainage basin contributary to this zone is somewhat more densely populated than that of Zone one, and it contains more sewered communities and industrial establishments.

The principal uses of the waters of the Delaware river in Zone two are expected to be for water supply, after treatment or purification, and for recreation, navigation, maintenance of fish and aquatic life, agricultural, industrial and other purposes.

Zone III: Zone three is that part of the Delaware river extending from the aforesaid line connecting the mouth of Pennypack Creek in Philadelphia and the corresponding point in New Jersey to the Pennsylvania - Delaware boundary line.

The drainage basin contributary to this zone contains populous metropolitan areas including Philadelphia, Pennsylvania, and Camden, New Jersey.

The principal uses of the waters of the Delaware river in Zone three are expected to be for navigation, industrial water supply, and other purposes.

The water in this zone, however, should be of such sanitary quality that it will not be unfit for use as sources of water supply, will not be harmful to fish life, and will not adversely affect the quality of the waters of the tidal tributaries.

Zone IV: Zone four is that part of the Delaware river extending from the Pennsylvania - Delaware boundary line to the Atlantic ocean.

The principal uses of the waters of the Delaware river in Zone four are expected to be for navigation, industrial water supply, commercial fishing, shellfish culture, recreation and other purposes.

In order to attain conditions of cleanliness and sanitation of the waters of the Delaware river which will be consistent with the appropriate existing and future quality and uses of such waters, the following minimum requirements shall apply to the several zones herein provided. It is the purpose and intent of such requirements to apply to artificial (not natural) causes of pollution.

## Article III

In order to put and maintain the waters of the Interstate Delaware river and its west branch as aforesaid, in a clean and sanitary condition, no sewage, industrial wastes or other polluting matter shall be discharged into, or be permitted to flow or fall into, or be placed in any respective zone of the interstate Delaware river as herein established, unless such sewage, industrial waste or other artificial polluting matter shall first have been so treated as to produce an effluent which will meet the following minimum requirements:

Zone 1: (1) Such effluent shall be free of noticeable floating solids, color, oil, grease, or sleek, and practically free of suspended solids.

(2) Such effluent shall be sufficiently free of turbidity that it will not cause noticeable turbidity in the water of the Delaware river.

(3) Such effluent shall show a reduction of organic substances of at least eighty-five per centum (85%) as measured by the bio-chemical oxygen demand, and furthermore, such effluent in no case shall exceed a biochemical oxygen demand of fifty (50) parts per million, and furthermore, the discharge of such effluent, after dispersion in the water of the river, shall not cause a reduction of the dissolved oxygen content of such water of more than five per centum (5%). The aforesaid reduction in dissolved oxygen content shall be determined by the average results obtained from dissolved oxygen tests made upon samples collected on not less than six (6) consecutive days from points in the river above and below the point or points of effluent discharge.

(4) Such effluent shall be of such quality that the most probable number of organisms of the Coli Aerogenes group shall not exceed one (1) per milliliter in more than ten per centum (10%) of the samples of sewage effluent tested by the confirmed test; and provided, further, that no single sample shall contain more than one hundred (100) organisms of the Coli Aerogenes group in one (1) milliliter.

(5) Such effluent shall be sufficiently free of acids, alkalis, and other toxic or deleterious substances, that it will not create a menace to the public health through the use of the waters of the Delaware river for public water supplies, for recreation, bathing, agriculture and other purposes; not be inimical to fish, animal or aquatic life.

(6) Such effluent shall be free of offensive odors and also be free of substances capable of producing offensive tastes and odors in public water supplies derived from the Delaware river at any place above or below the discharge of such effluent.

Zone 2: (1) Such effluent shall be free of noticeable floating solids, color, oil or grease, and practically free of both suspended solids and sleek.

(2) Such effluent shall be sufficiently free of turbidity that it will not cause noticeable turbidity in the water of the Delaware river.

(3) Such effluent shall show a reduction of organic substance of at least eighty-five (85) per centum as measured by the bio-chemical oxygen demand, and furthermore, such effluent in no case shall exceed a bio-chemical oxygen demand of one hundred (100) parts per million, and furthermore, the discharge of such effluent, after dispersion in the water of the river, shall not cause a reduction of the dissolved oxygen content of such water of more than ten (10) per centum. The aforesaid reduction in dissolved oxygen content shall be determined by the average results obtained by dissolved oxygen tests made upon samples collected on not less than six (6) consecutive days from points in the river above and below the point or points of effluent discharge.

(4) Such effluent shall be of such quality that the most probable number of organisms of the Coli Aerogenes group shall not exceed one (1) per milliliter in more than twenty-five (25) per centum of the samples of sewage effluent tested by the confirmed test; and provided, further, that no single sample shall contain more than one hundred (100) organisms of the Coli Aerogenes group in one (1) milliliter.

(5) Such effluent shall be sufficiently free of acids, alkalis, and other toxic or deleterious substances, that it will not create a menace to the public health through the use of the water of the Delaware river for public water supplies, for recreation, industrial and other purposes; nor be inimical to fish, animal or aquatic life.

(6) Such effluent shall be free of offensive odors and also be free of substances capable of producing offensive tastes or odors in public water supplies derived from the Delaware river at any place below the discharge of such effluent.

Zone 3: (1) Such effluent shall be free of noticeable floating, solids, oil or grease, and substantially free of both suspended solids and sleek.

(2) Such effluent shall be sufficiently free of turbidity that it will not cause substantial turbidity in the water of the Delaware river after dispersion in the water of the river.

(3) Such effluent shall show a reduction of at least fifty-five (55) per centum of the total suspended solids and a reduction of not less than thirty-five (35) per centum of the bio-chemical demand. (It is the intent of this requirement to restore the dissolved oxygen content of the river water in this zone to at least fifty (50) per centum saturation. To accomplish this it may be necessary in the case of certain wastes, to obtain reductions greater than those required under this item.)

(4) Such effluent, if it be discharged within two miles of a public water works intake or within prejudicial influence thereof, shall at all times be effectively treated with a germicide.

(5) Such effluent shall be sufficiently free of acids, alkalis, and other toxic or deleterious substances, that it will not create a menace to the public health through the use of the waters of the Delaware river for public water supplies, or render such waters unfit for industrial and other purposes; or cause the water of the Delaware river to be harmful to fish life.

(6) Such effluent shall be practically free of substances capable of producing offensive tastes or odors in public water supplies derived from the Delaware river.

Zone 4: (1) Such effluent shall be free of noticeable floating solids, oil, or grease, and substantially free of both suspended solids and sleek.

(2) Such effluent shall be sufficiently free of turbidity that it will not cause substantial turbidity in the waters of the Delaware river after dispersion in the water of the river.

(3) Such effluent shall show a reduction of at least fifty-five (55) per centum of the total suspended solids and shall be subject to such further treatment as may be needed to prevent a nuisance.

(4) Such effluent, if it be discharged within prejudicial influence of a public water works intake, or of recreational areas, or of shellfish grounds, shall at all times be effectively treated with a germicide, except that in the case of recreational area influence, such treatment need not be provided during the period from October fifteenth to May fifteenth of each year.

(5) Such effluent shall be sufficiently free of acids, alkalis, and other toxic or deleterious substances that it will not create a menace to the public health through the use of the waters of the Delaware river for public water supplies or render such waters unfit for commercial fishing, shellfish culture, recreational, industrial, or other purposes.

(6) Such effluent shall be practically free of substances capable of producing offensive tastes or odors in public water supplies derived from the Delaware river.

It is further recognized by the signatory States that the quality of the waters of the intrastate tributaries of the Delaware river and its aforesaid west branch are of interstate concern at their points of confluence with the Delaware river and its west branch. Therefore, it is also agreed that sewage, industrial waste or other artificial polluting matter discharged into, or permitted to flow or to fall into, or be placed in any intrastate tributary of the aforesaid Delaware river shall be treated to that degree, if any, necessary to maintain the waters of such intrastate tributary immediately above its confluence with the aforesaid Delaware river in a condition at least equal to the clean and sanitary condition of the waters of the Delaware river immediately above the confluence of such tributary.

Analyses and tests regarding the minimum requirements herein prescribed, shall be determined in accordance with the provisions contained in the American Public Health Association's latest edition on "Standard Methods for the Examination of Water and Sewage."

The aforesaid requirements as to treatment of sewage, industrial wastes or other artificial polluting matter and as to the sanitary quality of receiving waters are minima. It is the intent and purpose of these requirements to accomplish reasonable and adequate control and correction of pollution. Due to the many variable factors involved, however, and to the impossibility of forecasting future developments with certainty, it may be necessary in the future to impose additional requirements, particularly in Zones two and three.

The minima herein prescribed therefore shall be considered the first steps toward attaining the objectives sought, and if necessary may be required to be supplemented in the case that the general application of such minimum requirements does not adequately improve and maintain the sanitary quality of the waters of the Delaware river.

END OF INCODEL STANDARDS

## Definitions

WATER QUALITY CRITERIA - Rules, tests or other information which will aid in making a decision regarding the suitability of quality of water for use. Includes objectives, guides, standards and goals as described herein.

WATER QUALITY INDICATOR - A water impurity or characteristic which serves as a measurement of quality and the suitability of water for particular uses. Examples of indicators are: DO, BOD, pH, chloride, sulfate and ABS. (To be used in Phase I.)

WATER QUALITY PARAMETER - Parameter is often used the same as indicator However, because of dictionary definition of parameter as a mathematical term, the term indicator is preferred when referring to quality of water. (To be used in Phase II, but may also be used in Phase I if desired.)

WATER QUALITY OBJECTIVES - Word descriptions of the quality of water desired for use. There should be objectives for each use. The descriptions should include the characteristics desired, or not desired, but need not include quantitative information. They need not be limited by the practicality of measurement. Guides or other criteria are needed to determine realization of the objectives. (Describes fairly well the work to be undertaken in Phase I.)

WATER QUALITY GUIDES - Quantitative information on the effects and limiting concentration of water pollutants with respect to uses of water. An example of a guide is a list of concentrations of a pollutant showing the uses affected by these concentrations and the nature of the effect. Another example is a curve showing the relationship of fluoride concentration in drinking water to the proportion of the population having dental fluorosis. Guides may be presented in the form of acceptable concentrations of pollutants for specific uses of water. (Guides should form the basis for Phase II.)

WATER QUALITY GOALS - Values for selected indicators which serve as the water quality target for a water pollution control program. Goals are usually set for particular geographical areas such as reaches of stream or areas of lakes. (Describes the work to be accomplished by Phase II.)

WATER QUALITY STANDARDS - Quantitative and qualitative descriptions of the quality of water normally acceptable for uses. Standards are usually established by a recognized organization or governmental agency. They should not be confused with regulations although standards may be promulgated as regulations. Standards may include objectives, guides and other criteria for evaluating water quality. (Final results based on both Phase I and II with other factors and information considered).

September 1964

## Water Quality Objectives and Guides

by George W. Burke, Jr.*

A water quality standard consisting solely of a list of specific measurements may be frequently misused by application without consideration of polluting substances which are not included in the list. In an attempt to prevent this, standards usually include statements such as the ones found in the 1962 Public Health Service Drinking Water Standards namely "Drinking water should contain no impurity which would cause offense to the sense of sight, taste or smell. Under general use, the following limits should not be exceeded." Then selective measurements which have been associated with the absence of objection are listed. Also "Drinking water shall not contain impurities in concentrations which may be hazardous to the health of the consumers. It should not be excessively corrosive to the water supply system. Substances used in its treatment shall not remain in the water in concentrations greater than required by good practice. Substances which may have deleterious physiological effects, or for which physiological effects are not known, shall not be introduced into the system in a manner which would permit them to reach the consumer." This if followed by a list of substances with limiting concentrations recommended and limiting concentrations which are grounds for rejection of the supply.

The preliminary statements should be considered as quality objectives and the list of substances with their limiting concentrations should be considered as guides. In one instance the guides are recommended and in the other the guides are used as grounds for rejection of the supply because the impurities constitute hazards to health.

Standards of water quality such as these can be written and used without the implication or connotation of regulations, for example, the World Health Organization's International Standards for Drinking Water. This document is not a regulation; it is provided to encourage uniformity in the examination of waters and the expression of results and provides a standard for what constitutes acceptable drinking water. It, however, can serve as a reference for the development of regulations with respect to drinking water.

With the above in mind we might state objectives of quality for the various uses of water and selected guides or references to applicable guides, which can be used to determine whether or not a water meets the objectives.

Although numerous groupings of water uses can be made for the purpose of stating quality objectives and guides, it would be desirable to consider groupings which represent either common usage or uses with similar quality requirements. For this purpose the following groups will be used.

---

* Chief, Water Quality Criteria and Practice Section, Technical Services Branch, Division of Water Supply and Pollution Control, Public Health Service, U.S. Department of Health, Education, and Welfare, Washington, D.C.

1. Municipal (including domestic)
2. Industrial (not including cooling)
3. Irrigation
4. Livestock and Wildlife
5. Recreation (including swimming, boating and other esthetic enjoyment)
6. Fish and Other Aquatic Life
7. Water Transportation, Cooling and Power Production
8. Waste Assimilation and Transport

## Municipal

A municipal water supply should contain no substances which will harm people drinking it, bathing in it, or otherwise using it, cause damage to or otherwise make difficult its transmission in the water supply system or its use in various types of equipment. Such a water should be free of organisms which could cause harm to health and organisms which indicate the presence of wastes which might contain disease causing organisms. It should be free of toxic or radioactive chemicals and substances which cause taste, odor, color turbidity. It should be free of minerals which cause undesirable physiological effects or economic damage. It should not be subject to extremes in alkaline or acid reaction and should have a pleasing temperature. Of course, it is recognized that evaluation of the quality of water against these objectives requires more specific guides. Such guides are available and adequate for most situations.

The Public Health Service Drinking Water Standards provide sufficient concentration guides for most substances likely to be found in waters at harmful levels. In specific instances, however, knowledge of the presence of harmful substances not listed requires consultation of additional references to determine limits for safety. Of the other numerous references available for evaluating the acceptability of specific impurities Water Quality Criteria, Second Edition is probably the most useful.

Source waters for municipal supplies should not contain substances which will prevent the usual methods of treatment for producing a suitable water supply. Conditions or substances which can impair the quality of water or interfer with its treatment and usefulness are listed as follows and the objective of pollution control should be to prevent them from being excessive.

1. Bacteria and other living organisms
2. Unnatural deposits in the stream, particularly when of sewage or other waste origin
3. Substances causing color, odor and taste
4. Floating materials such as oils, grease, foam, sewage solids and refuse
5. Toxic and radioactive chemicals
6. Decomposable organic matter
7. Extremes in pH
8. Minerals, particularly those not removed by ordinary treatment
9. Elevated temperatures.

## Industrial

Objectives for industrial water supplies can be expressed much the same as those for municipal supplies. Although the industrial group includes a much larger variety of uses with special quality needs the objective of quality is to prevent damage to equipment and product and to persons involved. It has often been claimed that waters suitable for municipal supply will be suitable for industrial use. There are exceptions however and when special needs exist special considerations of quality must be made. Guides for making these considerations are provided in water quality criteria.

## Irrigation

Waters over a wide range of quality can be used for irrigation. However, with a lowering of quality there is an increase in the problems of irrigation water management and a decrease in the crops which can be successively irrigated. Some aspects of quality will not only reduce the water's utility but will make it unsuitable as an irrigation supply for certain crops.

Quality for irrigation is measured principally in terms of its salt content, however, consideration must also be given to the presence of living organisms and radioactive or other substances which could be toxic to or contaminate the crops being irrigated and impair their quality, or which could be leached into and contaminate the ground water. The quality objectives for irrigation water should include:

1. The absence of salts in concentrations which will harm the plants or the soil or which will require excessive quantities of water to leach the salts from the soil solution.
2. The absence of toxic substances in concentrations which will be harmful to crops or contaminate them and thereby harm consumers.
3. The absence of substances which will be leached into and contaminate the ground waters.
4. The absence of living organisms which will contaminate the crops or harm people working the irrigated fields.

Of the numerous references providing guides for evaluating the safety and utility of an irrigation water, Water Quality Criteria, Second Edition is probably the most useful.

## Livestock and Wildlife

It has been assumed that water safe for humans would be safe for livestock and even though animals have greater tolerance to many substances than humans it is desirable that for highest production they be provided water meeting the Drinking Water Standards. In considering objectives of quality or for pollution control, it should be remembered that livestock and wildlife must be able to use the water directly from streams.

Pollution control programs for protecting water for livestock and wildlife should provide waters which are free from, or do not contain sufficient amounts of the following substances to cause harm to animals either drinking them or swimming in them.

1. Bacteria or other living organisms.
2. Unnatural sediment or deposits particularly when from sewage or other waste origin.
3. Floating materials such as oil, grease, foam, sewage solids and refuse.
4. Substances causing objectionable color, odor, and taste.
5. Toxic and radioactive chemicals.
6. Decomposable organic matter.
7. Minerals.

Although guides for limiting the amounts of undesirable substances are not very plentiful, some useful information is contained in Water Quality Criteria, Second Edition.

## Recreation

The enjoyment of water for recreation depends not only upon its quality with respect to toxic, irritating and infectious substances but also its quality with respect to the senses. Characteristics or quality of water which affect its usefulness as a recreation water for swimming, boating or other esthetic enjoyment are included as follows:

1. Visible floating suspended and suspended solids (particularly when from sewage, industrial or other waste origin)
2. Sludge banks
3. Slime infestation
4. Heavy growths of attached plants or animals
5. High concentrations of plankton
6. Discoloration or excessive turbidity from sewage, industrial wastes or even material sources
7. Evolution or gases especially $H_2S$
8. Visible oils and greases including emulsions
9. Excessive acidity or alkalinity
10. Surface active agents which cause foam when aerated or agitated
11. Elevated temperatures which would be objectionable directly or would cause cloudness above the water because of excessive evaporation
12. Living organisms which can cause health impairment

Objectives for quality of waters suitable for recreation should include the following: 1) They should be esthetically enjoyable, i.e., free from obnoxious floating or suspended substances, objectionable color and foul odors; 2) they should contain no substances that are toxic upon ingestion or irritating to the skin of human beings; 3) should be reasonably free of organisms which produce disease or other health impairment and organisms which indicate the presence of wastes which could contain them; and 4) they should be free of substances which would impair safety.

Much of the quality desired is stated subjectively and not many guides for limits of undesirable substances are availalbe. However, Water Quality Criteria, Second Edition provides considerable information on what is being used.

## Fish and Other Aquatic Life

Fish and other aquatic life are sensitive to a myriad of water impurities and extensive studies have been conducted to relate their effects on this use. Even so the many problems of variations in investigating procedures, standardization of terms and the interrelationships of various water impurities have prevented the definition of the quality of water which is suitable for propogation of fish and other aquatic life. Although details regarding the effects of particular impurities in specific situations must be considered on an individual basis, the following can be listed as important factors of quality of water for this use: Dissolved oxygen, pH, ionizing salts as indicated by conductivity, light penetration as influenced by color and turbidity, temperature, toxic and radioactive substances, substances which would cause objectionalbe taste and odor in fish flesh.

The objectives of pollution control to protect waters for fish and other aquatic life should include the prevention of changes, as measured by the conditions or quality factors listed above, which would impair production of the normal aquatic fauna and flora of the particular area. Consideration should also be given to possible contamination with organisms, or radioactive or toxic substances, which may not adversely affect the fauna and flora, but would be harmful to consumers of aquatic foods contaminated with them (for example, the concentration of mercury in shellfish as in the Minamata case and virus contamination of clams resulting in infectious hepatitus outbreak.)

Guides for determining a water's suitability would vary from place to place and with differences in waters because the interrelationships of the impurities in the water and the combined effect on the aquatic life. For relatively clean water, guides have been recommended (see Water Quality Criteria, Second Edition), but as the number and variety of impurities in water increase, evaluation becomes more difficult and much research is needed to determine no-effect levels.

## Water Transportation, Cooling, and Power Production

It has sometimes been stated that these uses require little in the way of quality. Even though this may be true, it should not be concluded that quality is not important to them. Damages which may result from impaired water quality include the following:

1. Corrosion, cavatation, and delignification as caused by excessive acid, alkali, salt and dissolved gases
2. Blockage of intake and channels and loss of reservoir capacity caused by floating debris and solids
3. Loss of hydraulic capacity, increased friction and loss of life of hulls caused by infestations of slimes, worms, barnacles and other growths living on nutrients in the water
4. Odors and other nuisances caused by decomposition of organic matter
5. Fire hazards and economic losses caused by oils and tars

The specification of limiting concentrations of substances which cause these damages is seldom used in quality standards, however, pollution control programs should include the objective of limiting the objectionable substances to as low a level as can be maintained with the usual methods of waste management, treatment, and disposal.

## Waste Assimilation and Transport

It should not be assumed that no amount of quality deterioration will affect a water's utility for assimilating and transporting waste because use of water for this purpose should be permitted only insofar as multiple use is not prevented. Even the poorest quality of water serving this purpose should also be useful for water transportation and should not create a nuisance. Therefore, when attempting to state objectives of quality for this use the following should be considered.

1. Diluting capacity for waste components which do not degrade and affect other uses - A water which contains a maximum allowable concentration of a given substance doesn't serve as a diluting water (e.g. a water containing 250 mgcl/l shouldn't be permitted to receive chloride wastes which will raise this concentration if the water is to be used subsequently for municipal and certain industrial supplies because it will damage these uses; a stream carrying a maximum load of radioactivity won't serve as a receiving stream for radioactive wastes).

2. Temperature influences greatly the capacity of a water to assimilate decomposable wastes. Increasing temperature speeds up decomposition and also reduces dissolved oxygen reserve.

3. Acids, alkalies, and toxic substances affect flora and fauna and therefore, influence the capacity of the water to assimilate decomposable wastes.

4. Dissolved oxygen must be present if decomposition of wastes is to be accomplished in a suitable manner without nuisance.

5. Oxygen demanding substances present in the water affect the capacity of the water to assimilate additional substances of this kind.

# "WATER QUALITY CRITERIA"*

By

GEORGE W. BURKE, JR.**

Describing the quality of water which we want becomes more difficult as we impose greater demands on a more or less fixed but unevenly distributed water resource. In water quality control programs, we attempt to describe quality of water because waters vary widely, one being suitable for a particular use while another is not, and most water uses are accompanied by changes in water quality. Water has buoyancy and is the most nearly perfect solvent; as a result, it can carry a myriad of substances in suspension or solution. It is these substances which determine water's utility, and in describing water quality, our attention is directed to them and the effects they produce on water uses or to physical, biological and chemical characteristics which may not specifically identify substances in water but have been associated with the usefulness of water.

In using quality to evaluate water's usefulness, we need criteria. Some criteria have been recommended as standards, some have been promulgated as regulations or requirements and some have been established as goals or objectives. Each serves its particular purpose but these various terms have created confusion in describing quality needs or desires.

If we define WATER QUALITY CRITERIA as rules, tests or guides which are useful in making a decision regarding a water's suitability (and this is how the dictionary defines them), we recognize the other terms as special types of criteria. WATER QUALITY REGULATIONS are descriptions of quality required by law. STANDARDS are quality descriptions backed by some authoritative body; they can be used as recommendations or requirements, or they can be promulgated as regulations. WATER QUALITY OBJECTIVES and GOALS are frequently used as descriptions of water which is desired or which is the target of a particular water pollution control program.

Early in the development of quality criteria for drinking water, the quality objective was simply stated as freedom from substances causing offense to the senses of sight, taste and smell. This was apparently a standard used by a State supreme court judge early in this century. He decided that the testimony of experts need not be weighed with tenderness and care to determine what constitutes wholesome water as any ordinary mortal knows whether water is fit to drink and use. Certainly we use the response of the senses as criteria of water quality, they help to place suspicion on a water, but additional criteria are needed to support a decision on suitability of water and control of its quality for various purposes.

---

* Presented at the Annual Meeting of the National Technical Task Committee on Industrial Wastes, San Francisco, California, November 18-20, 1964.

**Chief, Water Quality Criteria and Practice Section, Technical Services Branch, Division of Water Supply and Pollution Control, Public Health Service, U. S. Department of Health, Education, and Welfare, Washington, D.C.

## Water Quality Control

Early in the last century, London found that waste waters had caused a deterioration of the quality of the River Themes and was impairing the water supply. In 1829, the Chelsea Water Works Company commenced filtering its water through sand to improve its quality. The quality criteria used were based on esthetics, the senses and possible doubts. At about the same time, a Royal Commission was appointed to study the London water supply situation. This Commission recommended moving the water supply intakes upstream where the water was less impure. It took over 20 years and the tragic experiences of two cholera epidemics to obtain action on this recommendation. The intakes were moved at about the same time that removal of the Broad Street pump handle, on recommendation of Dr. Snow, terminated the epidemic and substantiated Dr. Snow's conclusion that polluted water was the most important vehicle transmitting the disease. A study of distribution of the disease showed that the area served Chelsea Water Works Company's filtered water suffered lower disease incidence. Even though the particular quality responsible for disease transmission could not be identified, knowledge that the water was affected by wastes and as a result caused people to become sick was sufficient to convince authorities to act. These actions constituted quality control without being able to measure the quality, only the effect of it.. More than 20 years went by before discoveries by Pasteur and Koch provided the foundation for bacterial analysis which supported the development of bacterial criteria for water quality.

During the early 1930's, observations in the western United States led to the conclusion that severe mottling of tooth enamel was caused by something in the drinking water. Not until a later developed chemical test for determining fluoride in water was applied to the affected areas was high fluoride demonstrated to be the cause.

These situations serve to illustrate the association of drinking water with diseases or other harmful effects before substances in the water could be identified and related to the undesirable effects, and how quality control criteria could be established before the quality could be described. Control measures prescribed to produce an acceptable quality can be based on a general description of quality or knowledge that the measures produce quality acceptable to the user or they can be based on a specific description of quality and knowledge that that particular quality has been acceptable to the user. The latter method is to be preferred because it permits more exacting design and a quality requirement, standard or goal for checking the product. Of course, much more detail regarding quality and its effects must be understood and even then some quality control activities which are requirements not based on specific quality might be required.

## Drinking Water Standards

A review of the development of the Public Health Service Drinking Water Standards will show how additions to knowledge of the effect of quality lead to more detail in the description of quality requirements. It also illustrates the need for facility and operating requirements to insure protection of that quality. In the report of the Commission recommending the 1914 standards a simple quality objective was stated as follows, ".....free from injurious effects upon the human body and free from offensiveness to the sense of sight, taste or smell." The Commission pointed out that the standard recommended was one of "limits of impurity" and not one of "purity". It also pointed out that, although knowledge of the water supply source, its treatment and storage, is desired to make a judgment on the safety of the supply, sometimes the procurement of reliable information is impractical and judgments must be based upon laboratory examinations. When laboratory examination is the sole basis of judgment, limits for those substances which are not actually dangerous should be more liberal and limits for those impurities which are of definitely dangerous character should be more restricting. The 1914 standard was one for bacteriological quality only because the Commission members could not reach agreement regarding the details on physical and chemical characteristics which should be required.

In 1925 revised standards included sections on source and protection, bacteriological quality, and physical and chemical characteristics. The bacteriological quality requirements were made more liberal. With regard to physical and chemical characteristics, it was stated that the water should be clear, colorless, odorless and pleasant to the taste, should be free from toxic salts and should not contain excessive amounts of soluble mineral substances nor chemicals employed in treatment. It was pointed out in the standards that the chemical and physical tests described need be made only when there was presumption that the water did not meet this objective and then the results of the tests should be compared to limits specified for determining suitability of the water.

The 1942 standard added sampling requirements for bacteriological examination. It adjusted some of the physical and chemical limits and added limits for additional chemicals; namely, fluoride, arsenic and selenium. It also added requirements to prevent over-treatment of softened waters.

The 1946 revision made adjustments in the system standards and in chemical limits, e.g., fluoride was raised from 1 ppm to 1.5 ppm.

The 1962 revision modified the system standards, the bacteriological standards and the chemical and physical limits. This standard added new limits for chemicals and radioactivity and deleted the requirements on softened waters.

Thus we see that the drinking water standards were revised four times in less than 50 years, each revision including more detail for defining water quality requirements and continuing to include water system requirements for protecting this quality. The additional detail was made possible by new information on the effect of quality and was made necessary by additional pollution or pollution potential.

## Quality and Other Water Uses

We seem to have done much more to develop criteria for drinking water quality than criteria for other water uses. Quality is important to most of the other uses and their needs must be considered by pollution control programs. Some of the other water uses, their needs and their effects on quality are briefly described.

### Irrigation

Water is required for plant growth and the quality of this water affects the growth and the soil supporting it. Some substances in the soil moisture are required and some can be directly harmful to the plant. As water is consumed by the plant, substances in the soil moisture may become concentrated if they are not leached away by water draining through the soil solution.. The quality of irrigation water determines the quantity required for transpiration and leaching to maintain a satisfactory quality of soil moisture. Quality of the soil moisture also determines the soil structure and thereby the irrigation and draining characteristics.

Although little has been demonstrated which provides good criteria, the biological quality of irrigation water is of concern to health authorities responsible for protecting consumers of the irrigated crop and workers in the irrigated fields. Another quality of concern is the effect of radioactivity and pesticides on irrigated crops.

### Industrial Water Supplies

Quality of water is important to industry because of the harm which can be caused directly by substances in the water. Our modern industry in many instances requires a very special quality of water which must be provided by special treatment. To industry, however, one of the greatest functions of water is the transport of wastes away from the site of use. Treatment is expected to remove most of the waste substances before the water is returned to streams. However, it is known that not all substances contributed by industrial processes are removed by present treatment methods. Even cooling, the largest industrial use of water, contributes impurities such as corrosion-inhibiting chemicals, disinfectant chemicals and organisms from various growths in the cooling systems. Waste heat, although not an impurity as such, is a physical characteristic which must be considered in judging the quality of water for various uses.

### Recreation

Quality of water determines to a great extent its utility for recreation. Some substances may make water uninviting to a swimmer, even though they may not cause the water to be unsafe. Some substances endanger the swimmer's health and some eliminate the aquatic life which contribute to the value of water as a recreation resource. Recreational use of water can damage its quality by the contribution of gasoline, oils and toilet wastes from boats, garbage from picnic areas and waste waters from fixed recreational installations and housing accomodating visitors.

These are but a few of the uses of water but they illustrate the necessity for considering both the quality needs and quality effects of water uses when multiple use is demanded.

State Requirements for Quality Protection

For the control of water pollution and maintaining quality needed for various uses requirements vary widely among the 50 states. Some use criteria similar to the early drinking water standards, whereas others have very comprehensive requirements. A brief review of selected States' requirements related to water quality protection will indicate their scope. Requirements are usually directed to waste water effluents or to stream water quality.

Examples of the former are:

State A - requires all effluents to be of primary treatment or better.
State B - requires effluents to be treated according to the classification of the stream receiving them, viz. those for raw wastes, those for primary or better effluents and those for secondary effluents.
State C - simply requires that effluents contain no substances which will be injurious to uses of the stream - these being described as domestic water supply, conduct of a commercial enterprise, and fish and wildlife propagation.

(Note that the requirements are tending toward stream quality)

Those States directing attention to the stream quality are:

State A - although regulating effluents, describes conditions in the stream which must be prevented, viz., 1) sludge deposits, 2) debris which would be unsightly or deleterious, 3) nuisances, color or odor, 4) toxicity harmful to life.
State B - states that materials which will cause pollution cannot be discharged - then describes pollution as: 1) floating material injurious to life, 2) substances depositing in the stream, 3) oxygen deficiency, 4) coliforms, 5) selected chemicals by concentration.
State C - sets water quality objectives for each river basin. These include specified limits for 1) Dissolved Oxygen, 2) Toxic Wastes, 3) Taste and Odor, 4) Color, 5) pH, 6) Dissolved Solids, 7) Temperature, 8) Fluoride, and 9) Special Conditions.
State D - classifies streams and sets water quality standards by classification including limits for 1) floating and settleable solids, 2) pH, 3) Dissolved Oxygen, 4) toxic and deleterious substances, 5) odor producing substances, 6) phenolic compounds, 7) sewage and waste effluents.

The variety of water pollution control or water quality protection requirements of the States probably results from a number of differences including: 1) the extent of the need in magnitude and variety to control pollution, 2) structure of State laws and regulations and 3) the location of responsibility for pollution control within the State government.

## Water Quality Objectives by Use

Notwithstanding the differences, the States' quality protection requirements have one thing in common, viz., the controls attempt to provide a quality of water in the stream to meet the needs of various water uses. The means of doing this and the quality of water produced are not always the same, even though the group of uses being protected may be the same. The difficulty of producing a given water quality varies with conditions at different locations, even though the quality desired for a specific use may be the same at all points of use. If we describe this desired quality in words, without quantification, we may be able to agree on a set of quality objectives for each water use, regardless of location. Then with these objectives in mind we can review pertinent quality guides which quantify quality and effect and the problems of producing desired quality and arrive at a compromise which describes the quality we can accept as a goal under a specific set of conditions.

Use of water of course are numerous but for practical purposes we can group them: 1) municipal, 2) industrial, 3) irrigation, 4) livestock and wildlife watering, 5) recreation including swimming, boating and other esthetic enjoyment, 6) fish and other aquatic life, 7) water transportation, cooling, and power production, 8) waste assimilation and transport.

A statement of water quality objectives for each of these uses should define the quality of water desired. This definition should not be concerned with how practical it is to obtain this quality or measure it by analytical tests. Take, for example, water for municipal and industrial uses. Such a water should not contain substances which will (1) harm people drinking it, bathing in, or otherwise using it, (2) cause damage to or otherwise make transmission difficult in a water supply system, or (3) damage industrial equipment or products manufactured. Such a water should be free of wastes and organisms which could harm health and cause disease. It should be free of toxic and radioactive chemicals and substances which cause taste, color, odor and turbidity. It should be free of minerals which cause undesirable physiological effects or produce economic damage. It should not be subject to extremes in alkaline or acid reaction and should have a pleasing temperature. Of course these, as quality objectives, leave much to be desired in the way of measurement. However, they do provide a framework within which measurements can be designed and a particular level of quality can be specified as a goal, a standard or a requirement by regulation. The current Public Health Service Drinking Water Standards cover most of the items and provide guides for determining compliance.

## Water Quality Guides

As used in this context water quality guides are water quality criteria organized in a way to facilitate the specification of quality to meet the objectives of a particular use. The information should aid in making a decision regarding the level of quality which should be provided to meet the needs of particular uses under a described set of conditions. Ideal guides would quantify the damages various levels of quality would cause particular uses. Such guides would enable the description of quality which would provide maximum benefits commensurate with costs of providing the quality.

An attempt is currently being made to develop a guide relating cost of municipal water supply purification to quality of the source water. Preliminary study has indicated that very good correlations exist between certain quality indicators and the cost of chemicals used to treat the water.

Even in the absence of ideal guides, organization of present knowledge of the effects of quality on uses can help in developing goals for a particular program. The best collection of this knowledge is found in Water Quality Criteria, Second Edition. Data from this and other sources are being assembled in what we call use-concentration spectra. A Spectra of concentrations for various water impurities, potential pollutants, or quality indicators, are listed alongside water uses affected by the impurity. Concentrations greater than the one opposite the use are damaging to the use. A study of the spectrum quickly shows the water uses which are damaged by any particular concentration of a water pollutant. With information on the value of the damage to these uses a damage figure could be developed for a particular quality deterioration or a benefit could be calculated for a particular quality improvement, in a given situation. Even without damage quantification, however, the relative importance of quality levels can be determined from the spectra.

Another form of guide is a tabulation of threshold concentrations of various pollutants for water uses. Using lines for the pollutants and columns for uses the tabulation quickly shows the critical concentration for any particular pollutant when attempting to protect multiple uses. The following will illustrate how such a tabulation could be presented. In the squares are several bits of information - each square for a particular water pollutant and a particular water use. In the upper half is a concentration which has been shown to be a limiting concentration of this pollutant for this particular use. Sometimes the concentration is a tolerable one or causes no impairment. When the square is divided by a diagonal line the concentration is a recommended limit but when the dividing line is horizontal the concentration should not be exceeded or the use may be denied. When there is a dotted line the value above the line is for treated water, i.e., drinking water (in Municipal column only) and the value below the line is for water before treatment, i.e., stream water. In the lower portion of the square is the lowest concentration which can be measured by available practical analytical methods.

To show how this tabulation might be used take a few examples from the attached illustration. Coliforms are shown to be limited to 1 in potable water and for source of municipal supply and for irrigation supply the recommended limit is 5000. For recreation involving swimming a limit of 2400 is recommended. A recommended limit of 70 is shown in the fish column - this is only for shellfish however. Note the analytical test will measure to levels below 1/100 milliliters.

Chromium is shown to be limited to 0.05 in drinking water, recommended at 5-300 in fish waters, 5-500 in livestock supplies and 3.4-17.3 in irrigation supplies.

The cyanide line shows that protection of fish will also protect municipal water supply. Likewish in the case of sulfate, protection of fish will provide protection of municipal and other supplies. One serious caution should be sounded for this table, viz., most of the values shown are taken from the literature concerned with specific tests - they show either effect or no effect levels and can hardly be used as recommendations for general application. The table does, however, give some idea of the relative importance of controlling a particular pollutant for protecting the various uses - it will aid in interpreting the significance of a particular concentration of a pollutant to the various uses. The figures in the table can and should be referenced so that the documented information can be studied further if desired.

## Water Quality Goals

For a comprehensive water pollution control program we need water quality goals. These goals describe a level of quality which should be exceeded at all times within the design conditions of the program. Before establishing these goals consideration should be given the quality needs of the uses to be made of the water, the penalties of not meeting these needs, the capability and economics of controlling the stream water quality while permitting all uses, and the administrative and political problems of pollution control. It should be recognized that this quality may not be as good as desired by some users but it should be as good as can be provided commensurate with the economy of the water use area.

To develop water quality goals for a given water use area one should determine the water uses to be protected. Considering the quality objectives of these uses and the potential pollution, a group of water quality indicators (or parameters) should be selected.

A review of water quality guides should reveal a critical concentration or level for each water quality indicator. For example, take the quality indicator "fluoride" and a group of uses as follows: municipal water supplies, industrial water supply, fish and other aquatic life, and stock and wildlife watering. The water quality objective for each of these uses might be to assure freedom from substances which would cause esthetic or physiological harm

or economic damage. The fluoride threshold for each might read as follows, respectively; 0.8, 1.0, 1.5, 10.0 and 5.0. Now if each of these uses is to be protected it is obvious that the water in the stream should be kept below 0.8 ppm fluoride. If the uses to be protected included only fish and aquatic life, irrigation and stock and wildlife watering the fluoride concentration might be permitted to rise to 1.5 ppm. The critical threshold limit would be selected and it would become the first choice for the water quality goal insofar as fluoride as an indicator is concerned. The critical figures for each quality indicator would be the first selection for water quality goals.

Consideration should then be given to the feasibility and costs of producing quality to meet these goals. When cost becomes an inhibiting factor, consideration should be given to the penalties of providing a poorer quality. A balance between these two will indicate the goals which should be established.

In the absence of sufficient cost data to make a decision, the best judgment available should be used in arriving at the goals. This judgment should be provided by those most concerned and responsible for the use of water and the control of pollution. Current research and future efforts should improve our capability for eliminating much of the subjective judgment required and for providing the data and system which will make obvious the optimum quality in any given set of conditions.

## WATER QUALITY GUIDES

| Indicator or Impurity | Municipal | Swimming | Fish | Livestock Wildlife | Irrigation | |
|---|---|---|---|---|---|---|
| Coli MPN / 100 ml | 1 / 5000 – / <1 | 2400 / <1 | 70* / <1 | | 5000 / <1 | |
| Cr+6 mg/l | 0.05 / <0.05 | | 5-300 / <0.05 | 5-500 / <0.05 | 3.4-17.3 / <0.05 | |
| CN mg/l | 0.01 0.2 / 0.01 | | 0.08-0.5 / 0.01 | | | |
| Phenols mg/l | 1.0 / 1.0 | | 2700 / 1.0 | 15,000 / 1.0 | | |
| Sulfate mg/l | 250 / 1.0 | | 90 / 1.0 | 250 2000 / 1.0 | 336-960 576 / 1.0 | |

* SHELL FISH WATERS